# Design Proposal Of A Microbial Fuel Cell For Electricity Generation Using Wastewater From A Treatment Plant

POSTER
Ph.D. Student: N
Journal: NONE

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The Microbial Fuel Cell MFC is a bioelectrochemical system capable of utilizing microorganisms as biocatalysts to transform chemical energy into electrical energy, making it a promising model for the circular bioeconomy. This study designed and constructed a Microbial Fuel Cell with carbon-based electrodes and used 6 L of effluents from a wastewater treatment plant as substrate. The anode design ensured microbial adhesion to the electrode surface generating a maximum current of 0.318 V, a maximum projected of 0.00726 A/cm$^2$, and 0.00605 A/cm$^3$ of volumetric current density. Furthermore, samples analyzed after treatment in a bioelectrochemical system generated a Chemical Oxygen Demand removal efficiency of 90%. Therefore, the MFC achieved a current intensity measurement produced by the total anaerobic heterotrophic bacteria in the effluents.

## Introduction

The global demand for energy and the need to limit carbon emissions have intensified the focus on sustainable energy sources. According to the Ineternational Energy Agency, on 2022 they reported a global electricity comsumption at 25,027.3 TWh. Fossil fuels accounted for about 63% of global elextricity with renewable sources contributing only 27%.

One of the major challenges humanity faces is balancing environmental protection with sustainable economic and energy growth. This has led to search for renewable energy sources, such as wind, solar, hydro, and geothermal power. In Latin Ameria, 75% of electricy is generated from renewable sources, altthough the expansion of these technologies often involves deforestations and the displacement of local communities. Consequently, there is a growing interest in alternative renewable sources like biomass.

A Microbial Fuel Cell MFC is a Bioelectrochemical system that can use microorganisms as biocatalysts to transform chemical energy into electrical energy. Such cells are considered an emerging energy technology; however, their ability to produce clean energy from organic matter in wastewater makes it a promising model for the circular bioeconomy, thus promoting environmental sustainability.

A general model of an MFC consists of an anode and cathode placed in an aqueous solution in chambers separated by a membrane. Microorganisms in the anode chamber oxidize the fuel, generating electrons and protons, which create an electric current as they are transferred to the cathode. Anode-responsive bacteria drive this oxidation process, producing protons and therefore electric current from the biomass. In the cathodic chamber, electrons and protons reduce oxygen to water, completing the circuit and generating electricity.

This research explores whether a Microbial Fuell Cell model using carbon-based electrodes can transform chemical energy into electricity using urban wastewater, aiming to create a low-cost, renewable energy source that aligns with circular bioeconomy principles for sustainable energy and economic development.

To do so, it was established to specifically evaluate the global electromotive force of the MFC and determine the projected density current and the volumetric density current to ensure the positivity of the presence of anode-responsive bacteria.

## Material and Methods

Two carbon-based anodes were created using stainless steel mesh, treated previously with $H_2SO_4$ for 24 hours, and coated with activated carbon. The cathode was made of graphite cylinders from Panasonic batteries, interconnected with copper wire. The membrane consisted of a conditioner filter part and a filter paper put together. The MFC was built with glass plates measuring 30cm x 15 cm x 20 cm and had a capacity of 6 L. The wastewater storage tank was connecte to the Microbial Fuel Cell (MFC) via a hose with a valve that regulates the flow rate. The MFC has two chambers divided by the previouslt described membrane. The MFC was connected to an air pump and a clamp meter (Figure1).

## Results and Discussion

The present design took as base the studies of Zheng et al. (2015), Scott (2016), and Palanisamy et al. (2019) [1,2,4]. The results indicates that while Zheng et al. (2015) 3D-CB/SSM electrodes maintin high current densities when scaled up, electrodes constructed with activated carbon exhibit significant drop in performance upon scaling [4]. Additionally, it was observed that increasing the bending angles enhances both projected and volumetric current densities, whereas reducing the angles leads to decreased performance. However, the optimal bending angles for ensuring bacterial adhesion end efficient electron transfer was found to be between 5° and 10°. As a result, the minimum voltage produced by the MFC was 0.12856 volts to generate an electric current of 56.3 mV. On contrary, the maximum voltage produced by the MFC was 0.13133 volts to generate a current of 257 mV. It was established in this regard that the maximum projected current density for a projected area of 57.5 $cm^2$ is 0.02448 A $cm^2$ and the minimum is 0.00021 A $cm^2$. Regarding the volumetric current density, the maximum current density is 0.02474 A $cm^3$ and the minimum is 0.00017 A $cm^3$.

Scott (2016) and Palanisamy et al. (2019) explored various designs for MFC, emphasizing the importante of electrode properties to ensure the microbial adhesion [1,2]. They also discussed the challenges behind maintaining physical and chemical parameters controlled. The present study highlights the impact of physical-chemical parameters on the bioelectrochemical system, where the maximum projected and volumetric current density was 0.03283 A $cm^2$ and 0.002736 A $cm^3$ on Jan. 26 and the maximum projected and volumetric current density was 0.01677 A $cm^2$ and 0.01397 A $cm^3$ on Jan. 27.

Then again, it was evident that the percentage of dissolved oxygen present in the cathodic chamber directly influenced the overall electromotive force of the MFC and therefore affect the electrical power output of the cell. On Jan. 25 and Jan. 26 the daily voltage remained stable around 0.13129 but dropped to 0.1286 V on Jan 27. The dissolved oxygen increased from 13.4% to 19.1%, stabilizing the voltage at 0.13126 V by the end of the day on Jan 27.

The Microbial Fuel Cell demonstrated a carbon removal efficiency exceeding 90% with six post-treatment wastewater samples showing chemical oxygen demand (COD) levels below the permisible limit of 250 mg O2/L, according to APHA standards. Liang et al. (2018) achieved similar results in a 1000 L MFC system, maintaining COD levels below 50 mg O2/L with 70%-90% removal rat, meeting China's strict discharge standards [3]. However, in the present study, despite achieving a 90% of efficiency, only two of the analyzed samples met de minimum class D water quality standards under Bolivia's Law 1333, indicating the need for extensive treatment for safe human consumption.

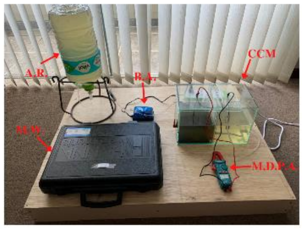


**Figure 1.** Result of the design Microbial Fuel Cell.

**Table 1.** Direct current versus time.

| Date | 0:00 | 0:30 | 1:00 | 1:30 | 2:00 | 2:30 | 3:00 | 3:30 | 4:00 | 4:30 | 5:00 | 5:30 | 6:00 | 6:30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24/01/22 | 96.7 | 21.7 | 19.4 | 14.30 | 5.80 | 7.0 | 4.80 | 8.70 | 16.70 | 83.10 | 51.50 | 60.9 | 66.1 | 70.9 |
| 28/01/22 | 64.9 | 131.2 | 154.4 | 173.9 | 169.1 | 170.8 | 174.2 | 188.5 | 180.1 | 213 | 180 | 213 | 181.7 | 188.9 |
| 31/01/22 | 175.5 | 251 | 246 | 271 | 250 | 253 | 276 | 280 | 299 | 298 | 297 | 301 | 258 | 336 |

## Conclusions

Is was concluded that the construction of an MFC based on carbon electrodes was achieved. The work a cell or a battery must perform to move electric charge through a circuit and generate an electric current was successfully produced thanks to the design. A MFC voltage was achieved that allowed us to measure the intensity of electric current produced by the total heterotrophic anaerobic bacteria from the effluents of the anaerobic lagoon of the wastewater treatment plant. Likewise, it was concluded that the COD removal efficiency reached a percentage higher than 90%.

***Acknowledgments***

Feel free to contact the organizing comittee for any further information.

***References***

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